Heartland Greenway Storage Site

QASP Attachment B: CO_2 Composition and Pipeline Schematics and Specifications

NAVIGATOR CO_2 VENTURES LLC

HEARTLAND GREENWAY

HEARTLAND GREENWAY SYSTEM

HGS DESIGN BASIS – P1

Rev.	Date	Description	By	Check'd	Appv'd
A	12/20/2021	Issue for P1 Project Development	CKM	MKC	NGK
B					
C					

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1.0 Purpose and Scope

1.1 This Design Basis is intended to outline the Navigator CO2 Ventures (NCO2V) Heartland Greenway System (HGS) design criteria, project pipeline segments, and facility nodes for a 1,357-mile gathering and transmission pipeline project to transport CO2 from sourced capture facilities to underground injection and sequestration. This is a confidential document for internal and external stakeholders who have executed a non-disclosure agreement, MSA, or MCA.

1.2 This Design Basis concentrates on the HGS defined responsibility which consists of the midstream pipeline segments and mainline booster pump stations while omitting the upstream (capture facilities) and downstream (sequestration facilities) scopes of responsibility. The initial use of the Design Basis is to determine the hydraulic horsepower and pipeline diameters while laying out the design philosophy and progression.

1.3 This document is intended to be non-technical in nature and a future Engineering/Technical Design Basis is planned for further engineering studies and design. Subsequent versions of these documents will include design criteria and philosophy specific to components of the CO2 pipeline system such as codes, standards, design criteria, and other data that team members need to perform design.

2.0 Pipeline Segments & Facility Nodes

The Heartland Greenway System (HGS) consists of six (6) Regions, which is further broken down into nineteen (19) pipeline segments and seven (7) facility nodes. The ROW Regions Map and SOW is included in the appendices. Pipeline segments may be further broken down using the construction spread methodology. The segments and nodes identified in this Section represent the current permitting scope which may vary from the baseline hydraulic model that includes an alternate scenario for initial construction. The project mileage totals 1,357 miles allocated into each region as outlined below:

2.1 **Region One** – HGS Illinois Trunkline and Big River Galva Lateral

Pipeline Segment	Summary
HGS Illinois Trunkline	~136 mi of 20”
Big River Lateral (Lateral 10.1)	~97 mi of 6”

Facility Node	Summary
Mainline Booster Station – Augusta, IL	3,050 HP (3 x 1,750 HP ea)

2.2 **Region Two** – HGS Trunkline Lee County, IA to Mahaska County, IA; OCI Trunkline; Big River W Burlington Lateral; SE Iowa Lateral

Pipeline Segment	Summary
HGS Trunkline – Lee Co., IA to Mahaska Co., IA	~109 mi of 20”
SE Iowa Lateral – ADM Cedar Rapids to ADM Clinton (Lateral 8)	~14.6 mi of 12”; ~66.3 mi of 8”

SE Iowa Lateral – HGS Trunkline to ADM Cedar Rapids (Lateral 8.1)	~70 mi of 12”
SE Iowa Lateral – ADM Cedar Rapids to BRR Dyersville (Lateral 8.2)	~49 mi of 6”
OCI Trunkline – HGS Trunkline to OCI IFCo (Lateral 10)	~12 mi of 8”; ~8 mi of 6”
O Lateral – BRR Interconnect to BRR W Burlington (Lateral 10.2)	~15 mi of 6”

Facility Node	Summary
Booster Station (SE IA Lateral) – Cedar Rapids, IA	270 HP (3 x 150 HP ea)
Mainline Booster Station – Libertyville, IA	3,170 HP (3 x 1,750 HP ea)

2.3 **Region Three** - HGS Trunkline Jasper County, IA to Hamilton County, IA; NE Iowa Lateral

Pipeline Segment	Summary
HGS Trunkline – Jasper Co, IA to Hamilton Co, IA	~86 mi of 20”
NE Iowa Lateral – HGS Trunkline to VLO Charles City (Lateral 7)	~99 mi of 6”

Facility Node	Summary
Mainline Booster Station – Story City, IA	1,850 HP (3 x 1,000 HP)

2.4 **Region Four** – HGS Trunkline Webster County, IA to O’Brien County, IA; Fort Dodge Lateral; Minnesota Lateral

Pipeline Segment	Summary
HGS Trunkline – Webster Co, IA to O’Brien Co, IA (Hartley)	~131 mi of 16”
Minnesota Lateral – VLO Lakota to VLO Welcome (Lateral 2)	~21 mi of 6”
Minnesota Lateral – Hartley to VLO Lakota (Lateral 3)	~50 mi of 8”; ~26 mi of 6”
Fort Dodge Lateral (Lateral 6)	~14 mi of 6”

Facility Node	Summary
Mainline Booster Station – Fort Dodge, IA	1,404 HP (3 x 800 HP)

2.5 **Region Five** – HGS Albion to Hartley Lateral (Nebraska Lateral)

Pipeline Segment	Summary
Nebraska Lateral – ADM Columbus to VLO Albion (Lateral 4.1)	~47 mi of 12”
Nebraska Lateral – VLO Albion to Hartley (Lateral 4.2)	~186 mi of 12”
Nebraska Lateral – NE Lateral to Siouxland Ethanol (Lateral 4.3)	~6 mi of 6”
Nebraska Lateral – NE Lateral to CF Sergeant Bluff (Lateral 4.4)	~3 mi of 6”

Facility Node	Summary
NE Lateral Booster Station – Germantown, IA	1,081 HP (3 x 600 HP)
NE Lateral Booster Station – Albion, NE	608 HP (3 x 350 HP)

2.6 **Region Six** – South Dakota Lateral

Pipeline Segment	Summary
South Dakota Lateral – Hartley to VLO Aurora	~122 mi of 8”

3.0 Design Benchmarks & Progression

The Design Process will utilize the P1 (30%), P2 (60%), P3 (90% / IFB), and IFC (100%) Benchmarks. Responsibilities for each deliverable are divided amongst NCO2V, Survey, and Engineering Firm. NCO2V will determine how each pipeline segment and facility node will be subdivided among several survey companies and engineering firms.

3.1 Pipeline and Facility - Preliminary Deliverables (P1)

3.1.1 Hydraulic study / verification (by Engineering Firm)

3.1.2 Engineering/Technical Design Basis (by Engineering Firm)

3.1.3 Process Flow Diagrams – PFDs (by Engineering Firm)

3.1.4 Load Study per facility node (by Engineering Firm)

3.1.5 Long Lead items identification and specification on HGS data sheets (by Engineering Firm)

3.1.6 Long lead item budgetary cost and lead time (by NCO2V)

3.1.7 Detailed Engineering itemized estimate and timeline for P2-IFC (by Engineering Firm)

3.1.8 +/- 10% AFE Quality – Project Estimate through installation (by NCO2V)

3.1.9 Project Execution Schedule through Installation (by NCO2V)

3.1.10 Permit Exhibits (Road/Railroad/Pipeline Crossings) (by Survey)

3.1.11 P1 Design Review (by NCO2V and Engineering Firm)

3.2 Pipeline and Facility – Detailed Deliverables (P2-IFC)

3.2.1 P&IDs w/ NCO2V Identifiers (by Engineering Firm)

3.2.2 Emergency Flow Restriction Device (EFRD) modeling for MLV locations including comprehensive HCA and ESA analyses (by Engineering Firm)

3.2.3 Piping Details of Facilities on 2-D drawings (by Engineering Firm)

3.2.4 3-D Models for all greenfield expansions (by Engineering Firm)

3.2.5 Civil and Foundation Design (by Engineering Firm)

3.2.6 Electrical One-Lines (by Engineering Firm)

3.2.7 Grounding and Lighting Plans (by Engineering Firm)

3.2.8 Conduit and Cable Schedules (by Engineering Firm)

3.2.9 Conduit Plan and Layout (by Engineering Firm)

3.2.10 System Communication Architecture – HGS Typical (by Engineering Firm)

3.2.11 Compile a Project I/O List (by Engineering Firm)

3.2.12 Termination Details (by Engineering Firm)

3.2.13 Arc Flash Study (by Engineering Firm)

3.2.14 Hazardous area classification plans (by Engineering Firm)

3.2.15 Process Hazard Assessments (PHA) for pipeline segments and facility nodes (by Engineering Firm)

3.2.16 Hydrotest Plan – segment summary and water volumes (by Engineering Firm)

3.2.17 Pipeline Foreign Line Crossing Summary (by Survey)

3.2.18 HDD Summary List (by Survey)

3.2.19 Bore Summary List (by Survey)

3.2.20 Bend List (by Survey)

3.2.21 Foreign Utility Crossing List (by Survey)

3.2.22 Main Line Valve summary (by Survey)

3.2.23 Pipe Tally and Summary (by Survey)

3.2.24 Main Line Valve site design and layout (by Engineering Firm)

3.2.25 Over Pressure Protection (OPP) Study (by Engineering Firm)

3.2.26 Pipeline and Facility BOM for all engineering disciplines (by Engineering Firm)

3.2.27 Buoyancy/Bends/MOP Design/etc (by Engineering Firm)

3.2.28 IFB Pipeline Installation Summary (By Survey)

3.2.29 IFB Pipeline Alignment Sheets (By Survey)

3.2.30 P2 Design Review (by NCO2V and Engineering Firm)

4.0 Design Basis & Hydraulic Assumptions

4.1 Hydraulic Modeling Software – Commercial pipeline network software approved by NCO2V will be used for the hydraulics modeling. The software program should be capable of solving differential equations governing steady-state and transient hydraulics analysis. The program must provide reliable modeling of pipelines, pumps, valves, and associated controls. The program will utilize the BWRS or Peng-Robinson equation of state for predicting CO2 properties throughout the system. The program should also predict heat transfer between the ground and pipeline in order to predict CO2 temperature at any point in the hydraulic model. The pipeline length used in the hydraulics study will initially be determined by desktop study of potential routes. The current baseline hydraulic model can be found in the appendices.

4.2 Pipeline Material & Installation Assumptions – Pipe utilized for the project shall be API 5L PSL-2 line pipe with a grade and wall thickness to accommodate the MOP of 2,200 psig at 100 °F using a design factor of 0.72 corresponding to the method described in ASME B31.4 Code and 49 CFR Part 195. Pipe grades shall be no higher than X-70. **NOTE: The potential exists for a temperature de-rating of the pipeline if the inlet product temperature is greater than 100 °F due to the design requirements of the ANSI 900 B16.5 Flange Ratings. Current plans allow shippers to inject at temperatures up to 120 °F.** A more conservative design factor may be selected for piping inside stations, in fabricated assemblies, HDD installations, road/railroad crossings, specific locations for control of ductile fractures, where state or local requirements deem it necessary, or as desired by NCO2V. The pipeline absolute roughness used for hydraulics will be 0.0007 in representing clean commercial steel pipe. Pipeline burial depth will assure a minimum depth of cover of 60 inches and meet the requirements of ASME B31.4 Code and 49 CFR Part 195. The average ground temperature assumed at pipeline depth will be 60°F for the Midwest region. The average soil conductivity assumed for the hydraulic analysis will be 0.55 Btu/hr-ft-F. This k value corresponds to average soil composition with normal moisture content. Use local data where available.

4.3 Wall Thickness – The pipeline diameter to wall thickness ratio (D/t) may not be greater than 96 to facilitate installation and reduce the potential for the occurrence of dents, buckles, and ovality. The hydraulic model uses the following line pipe assumptions which are subject to further change throughout the design process.

Nominal Pipe Size (NPS)	Material of Construction	Baselay Wall Thickness (in)	MOP - DF = 0.72 per B31.4 (psig)	HDD/Bore Wall Thickness (in)	MOP - DF = 0.60 per B31.4 (psig)
6	Carbon Steel | API 5L PSL-2 | X70 | ERW	0.250	3,804	0.280	3,550
8	Carbon Steel | API 5L PSL-2 | X70 | ERW	0.250	2,922	0.280	2,727
12	Carbon Steel | API 5L PSL-2 | X70 | ERW	0.312	2,467	0.375	2,471
16	Carbon Steel | API 5L PSL-2 | X70 | ERW	0.375	2,363	0.500	2,625
20	Carbon Steel | API 5L PSL-2 | X70 | ERW	0.500	2,520	0.625	2,625

4.4 Design Flow Rate – In order to establish pipeline sizes, the estimated total supply for the HGS is 9,341,114 Tonnes/yr (486.5 MMscfd) which is used as the baseline model design flow rate. Due to ongoing commercial development several alternate hydraulic models exist with varying flow rates or different source capture facilities which are not included here. The number of pipeline segments in the baseline hydraulic model may vary from §2.0 due to confidentiality of potential shipper information.

4.5 Shipper Delivery Pressure – The receipt pressures from all sources into the pipeline must be capable of delivering to the HGS at 2,200 psig but will target 2,100 psig for hydraulic design and operations.

4.6 Sequestration Delivery Pressure – The minimum delivery pressure at sequestration will be 1,300 psig.

4.7 HGS Operating Pressure – All HGS Laterals, Trunkline, facilities, and metering shall have a MOP of 2,200 psig at 100 °F. The minimum booster station suction pressure will be 1,300 psig. The maximum booster station discharge pressure shall not exceed the pipeline MOP of 2,200 psig. For system hydraulics design, the maximum discharge pressure should not exceed 2,100 psig.

4.8 CO2 Properties and Shipper Limits – In order to achieve the highest amount of mass flow, the CO2 will be transported in a dense phase. The source CO2 composition will be analyzed for specific fluid properties (density, viscosity, and enthalpy) to confirm the minimum pipeline pressure above critical point. The minimum pipeline pressure for the hydraulic analyses will otherwise be 13,00 psig as compared to the critical pressure of approximately 1,077 psig. The shipper limit (NCO2V product specification) and average CO2 composition for the receipt points used in these analyses is shown in the table below:

COMPONENT	SHIPPER LIMIT	AVERAGE RECEIPT
Carbon Dioxide (CO2)	>98 mol%	98 mol%
Water (H2O)	< 20 lb/MMSCF (422 ppmv)	15 lb/MMSCF (422 ppmv)
Total Hydrocarbons	<2 mol%	1 mol%
Inerts (sum of N2, O2, Ar, H2)	<2 mol%	1 mol%
Hydrogen (H2)	<1 mol%	0.5 mol%
Oxygen (O2)	< 100 ppmv	50 ppmv
Hydrogen Sulfide (H2S)	< 100 ppmv	20 ppmv
Total Sulfur	< 100 ppmv	20 ppmv
Carbon Monoxide (CO)	< 100 ppmv	50 ppmv
Glycol	< 1 ppmv	0.5 ppmv

Average receipt composition properties for various temperatures and pressures are shown in the following table:

Temperature (°F)	Pressure (psig)	Density (lb/ft3)	Viscosity (cP)
60	1300	53.4	0.091
95	1300	35.6	0.044
110	1300	21.7	0.027
60	2100	57.2	0.11
110	2100	44.4	0.063

APPENDIX A – Baseline Hydraulic Model

Not Responsive - Ex. 4

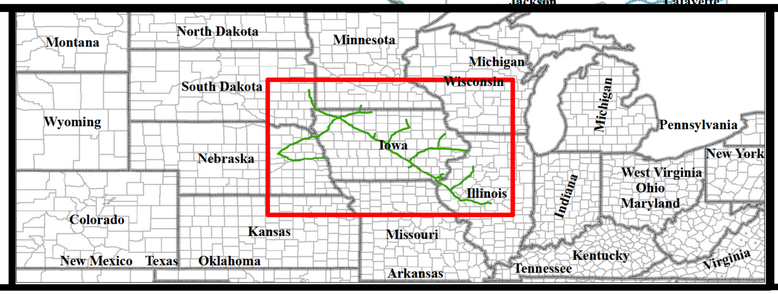
Not Responsive - Ex. 4

APPENDIX B – ROW Regions Map and SOW

REGION 1
REGION 2
REGION 3
REGION 4
REGION 5
REGION 6

Minnesota
South Dakota
Wisconsin
Nebraska
Iowa
Kansas
Missouri
Illinois

Legend
- Heartland Greenway – Proposed Centerline
- Centerline County
- Counties
- States



Heartland Greenway System

1365.80 total miles

NAVIGATOR CO2 VENTURES LLC

0 105 210 420 630 840 Miles

TOPOGRAPHIC LOYALTY INNOVATION LEGACY

ROW Services-Phase 1 Scope of Work (Pre-Acquisition)

HGS KMZ –Optimized Routes 10-25-21

ROW Regions as Follows *(Region based on proposed direction of construction)*

- **Region One: HGS Illinois Trunkline and Lateral 10.1**
  - Approx. 232.41 mi of Pipeline
  - Thirteen (13) Counties
    - 10.1 Galva
  - (994) Centerline Parcels w/ (704) unique landowners

- **Region Two: HGS Trunkline Lee Co. to Mahaska Co. & Lateral Lines 8, 8.1, 8.2, 10, & 10.1**
  - Approx. 344 mi of Pipeline
  - Fourteen (14) Counties
    - 8-Clinton to Cedar Rapids
    - 8.1-Cedar Rapids
    - 8.2-BR Dyersville
    - 10-OCI-Trunkline
    - 10.2-BR W Burlington
  - (1856) Centerline Parcels w/ (976) unique landowners

- **Region Three: HGS Trunkline Jasper Co. to Hamilton Co. & Lateral 7**
  - Approx. 185.5 mi of Pipeline
  - Nine (9) Counties
    - 7-Charles City to Ames
  - (910) Centerline Parcels w/ (529) unique landowners

- **Region Four: HGS Trunk line Webster Co. to O'Brien Co. & Laterals 2, 3, & 6**
  - Approx. 228.2 mi of Pipeline
  - Nine (9) Counties
    - 2-Welcome to Lakota Iowa and Minnesota
    - 3-Lakota to Hartley Iowa
    - 6-Fort Dodge Iowa
  - (1165) Centerline Parcels w/ (591) unique landowners

- **Region Five: HGS Albion to Hartley Lateral 4.2 & 4.1, 4.3, 4.4**
  - Approx.245 mi of Pipeline
  - Ten (10) Counties
    - 4.1-Columbus to Albion
    - 4.2-Albion to Hartley
    - 4.3-Hwy 20 to Hwy 35
    - 4.4-Sargent Bluff
  - (879) Centerline Parcels w/ (608) unique landowners

- **Region Six: HGS Aurora to Hartley Iowa O'Brien Co. to Lyon Co. & South Dakota (aka Lateral 1)**
  - Approx.121.9 mi of Pipeline
  - Five (5) Counties
  - (548) Centerline Parcels w/ (400) unique landowners

APPENDIX C – BASEINE Capture Facility Summary

NCO2V HGS CAPTURE FACILITY SUMMARY

Plant	Type	bpd	MMgy	CO2 Stream	Mty	MMSCFD	Lat	Long	Elev	State	County	Line
VLO - Albert City	Ethanol	7,875	135	Pure	365,028	19.011	42.773656	-94.941697	1,310	IA	Buena Vista	ML Injection
VLO - Albion	Ethanol	7,291	125	Pure	337,989	17.603	41.678622	-97.977219	1,735	NE	Boone	Nebraska Lateral
VLO - Aurora	Ethanol	8,458	145	Pure	392,067	20.420	44.293453	-96.692486	1,636	SD	Brookings	SD Lateral
VLO - Charles City	Ethanol	8,458	145	Pure	392,067	20.420	43.097167	-92.745839	1,055	IA	Floyd	NE Iowa Lateral
VLO - Hartley	Ethanol	8,458	145	Pure	392,067	20.420	43.175839	-95.501925	1,460	IA	Obrien	ML Injection
VLO - Lakota	Ethanol	2,917	50	Pure	135,196	7.041	43.384503	-94.142778	1,150	IA	Kossuth	MN Lateral
VLO - Welcome	Ethanol	8,458	145	Pure	392,067	20.420	42.025428	-93.510972	1,250	MN	Martin	MN Lateral
VLO - Fort Dodge	Ethanol	8,458	145	Pure	392,067	20.420	42.510958	-94.300814	1,143	IA	Webster	ML Injection
ADM - Cedar Rapids	Ethanol	32,665	560	Pure	1,536,876	80.044	41.925173	-91.691560	744	IA	Linn	SE Iowa Lateral
ADM - Clinton	Ethanol	10,208	175	Pure	461,063	24.013	41.817036	-90.217019	600	IA	Clinton	SE Iowa Lateral
ADM - Columbus	Ethanol	21,582	370	Pure	1,100,962	57.340	41.417425	-97.289918	1,423	NE	Platte	Nebraska Lateral
Cargill - Blair	Ethanol	12,250	210	Pure	630,000	32.812	41.529732	-96.100094	1,005	NE	Washington	Nebraska Lateral
Cargill - Fort Dodge	Ethanol	7,583	130	Pure	351,508	18.307	42.507634	-94.312999	1,146	IA	Webster	ML Injection
Cargill - Eddyville	Ethanol	2,917	50	Pure	188,875	9.837	41.140181	-92.641325	671	IA	Monroe	Eddyville Lateral
CF Industries	Ethanol	6,416	110	Pure	300,000	15.625	42.335890	-96.381432	1,080	IA	Woodbury	Nebraska Lateral
Siouxland Ethanol	Ethanol	7,291	125	Pure	232,834	12.126	42.455524	-96.598403	1,142	NE	Dakota	Nebraska Lateral
Koch - Fort Dodge	Ethanol	5,833	100	Pure	250,000	13.021	42.498104	-94.019941	1,106	IA	Webster	Fort Dodge lateral
Big River Resources - Dyersville	Ethanol	7,291	125	Pure	351,508	18.307	42.487408	-91.164684	962	IA	Delaware	SE Iowa Lateral
Big River Resources - Galva	Ethanol	7,291	125	Pure	351,508	18.307	41.169724	-90.022244	826	IL	Henry	Big River Lateral
Big River Resources - W Burlington	Ethanol	5,833	100	Pure	297,430	18.307	40.831154	-91.222981	715	IA	Des Moines	O Lateral
OCI IFCo	Fertilizer	11,865	203	Pure & Post	490,000	25.520	40.693178	-91.230246	544	IA	Lee	O Lateral
		199,399	3,418		9,341,112	489.321						

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CO2 COMPOSITIONS
Upstream/Downstream of Capture Equipment

ETHANOL GENERATOR

CO2 Composition upstream of Capture Equipment:

Species	Dry Basis Composition	Wet Basis Composition
	mole%	mole%
Carbon Dioxide	99.82	87.11
Water	--	12.73
	ppmv	ppmv
Nitrogen*	600	524
Oxygen*	100	87
Ethanol	950	830
Methanol	50	44
Acetaldehyde (+ trace aldehydes)	75	66
Ethyl acetate (+ trace esters)	33	29
Acetone	3	2.2
C_3+ alcohols	5	4.4
Hydrogen sulfide (+ trace S species)	6.5	5.7
Methane	3	2.6

* Concentrations of N_2 and O_2 in the range of 0-5mol% are sometimes encountered if air is used for purging the fermenter gas system.

CO2 Composition downstream of Capture Equipment:

Component		Unit
Minimum CO2	>98	mole%, dry basis
Water content	<20	lb/MMscf
Impurities (dry basis):		
Total Hydrocarbons	<2	mol%
Inerts (N2, Ar, O2)	<2	mol%
Hydrogen	<1	mol%
Glycol	<1	ppmv
Hydrogen Sulfide	<100	ppmv
Total Sulfur	<100	ppmv
Oxygen	<100	ppmv
Carbon monoxide	<100	ppmv
Glycol	1	ppmv

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FERTLIZER GENERATOR

CO2 Composition upstream of Capture Equipment:

Species	Dry Basis Composition	Wet Basis Composition
	mole%	mole%
Carbon Dioxide	99.5+	~92-93
Water	--	~7-8
	ppmv	ppmv
Hydrogen	<1000	<1000
Nitrogen	<100	<100
Oxygen	<10	<10
Total Hydrocarbons	<100	<100
Carbon Monoxide	<30	<30
Hydrogen sulfide (+ trace S species)	<10	<10

CO2 Composition downstream of Capture Equipment:

Component		Unit
Minimum CO2	>98	mole%, dry basis
Water content	<20	lb/MMscf
Impurities (dry basis):		
Total Hydrocarbons	<2	mol%
Inerts (N2, Ar, O2)	<2	mol%
Hydrogen	<1	mol%
Glycol	<1	ppmv
Hydrogen Sulfide	<100	ppmv
Total Sulfur	<100	ppmv
Oxygen	<100	ppmv
Carbon monoxide	<100	ppmv
Glycol	1	ppmv

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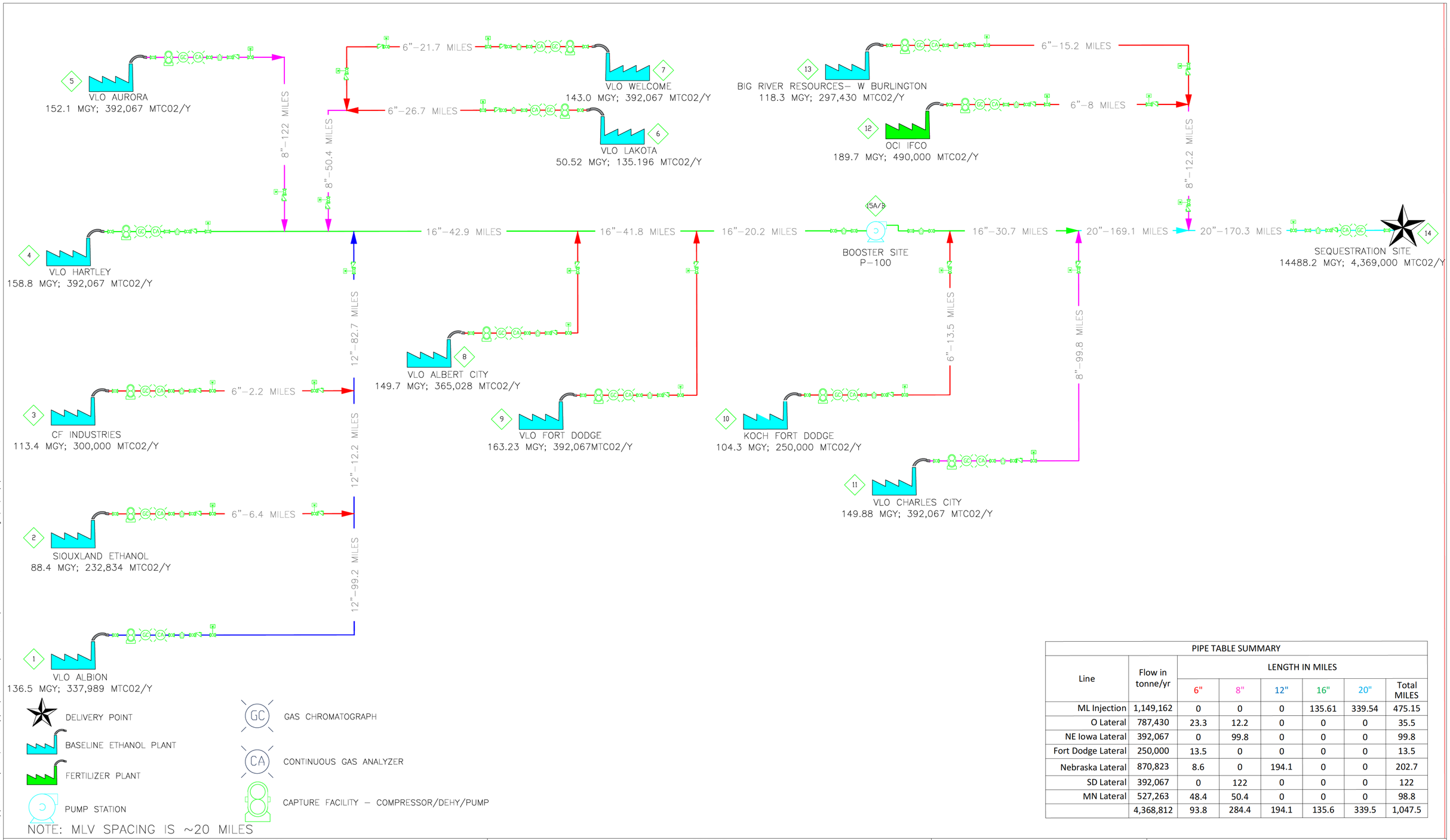
POST COMBUSTION

CO2 Composition upstream of Capture Equipment:

(would like to compile compositions of several potential post combustion quality streams by generator type)

CO2 Composition downstream of Capture Equipment:

Component		Unit
Minimum CO2	>98	mole%, dry basis
Water content	<20	lb/MMscf
Impurities (dry basis):		
Total Hydrocarbons	<2	mol%
Inerts (N2, Ar, O2)	<2	mol%
Hydrogen	<1	mol%
Glycol	<1	ppmv
Hydrogen Sulfide	<100	ppmv
Total Sulfur	<100	ppmv
Oxygen	<100	ppmv
Carbon monoxide	<100	ppmv
Glycol	1	ppmv



NOTE: MLV SPACING IS ~20 MILES

PIPE TABLE SUMMARY							
Line	Flow in tonne/yr	LENGTH IN MILES					
		6"	8"	12"	16"	20"	Total MILES
ML Injection	1,149,162	0	0	0	135.61	339.54	475.15
O Lateral	787,430	23.3	12.2	0	0	0	35.5
NE Iowa Lateral	392,067	0	99.8	0	0	0	99.8
Fort Dodge Lateral	250,000	13.5	0	0	0	0	13.5
Nebraska Lateral	870,823	8.6	0	194.1	0	0	202.7
SD Lateral	392,067	0	122	0	0	0	122
MN Lateral	527,263	48.4	50.4	0	0	0	98.8
	4,368,812	93.8	284.4	194.1	135.6	339.5	1,047.5

REFERENCE DRAWINGS

DRAWING NO	DESCRIPTION

REVISIONS

No	DESCRIPTION	BY	CHKD	APPV'D	DATE
D	ISSUED FOR APPROVAL	BSP	JAS	JAS	03/02/22
C	ISSUED FOR APPROVAL	BSP	JAS	JAS	02/28/22
B	ISSUED FOR REVIEW	BSP	JAS	JAS	02/22/22
A	ISSUED FOR REVIEW	BSP	JAS	JAS	02/15/22

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HEARTLAND GREENWAY SYSTEM

C02 PIPELINE FEED
PROPOSED SYSTEM MAP

SCALE:	PROJECT NO:	DRAWING NO.	REV:
N.T.S.	2201–0001	HGS–2201–F–00001	D

STATION CONDITIONS														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
FLOW (MGY)	136.51	88.42	113.37	158.76	152.08	50.52	143.04	149.65	163.23	104.25	149.88	189.74	118.28	1488.24
FLOW (MTCO2/Y)	337,989	232,834	300,000	392,067	392,067	135,196	392,067	365,028	392,067	250,000	392,067	490,000	297,430	4,369,000
FLOW (MMSCFD)	17.817	12.274	15.815	20.668	20.668	7.1269	20.668	19.243	20.668	13.179	20.668	25.831	15.679	230.3
PRESSURE (PSIG)	1742	1925	1953	1736	1861	1997	2100	1701	1583	1909	1915	1983	1900	1300
TEMPERATURE (F)	100	100	100	100	100	100	100	100	100	100	100	100	100	67.7
DENSITY (LB/FT^3)	40.8	43.4	43.6	40.7	42.5	44.1	45.2	40.2	39.6	43.1	45.2	44.0	43.0	48.6

PUMP CONDITIONS		
	15A	15B
HP	358.5	358.5
FLOW (MGY)	1024.42	1024.42
FLOW (MTCO2/Y)	3,189,000	3,189,000
FLOW (MMSCFD)	157.54	157.54
PRESSURE (PSIG)	1593	1852
TEMPERATURE (F)	77.4	84.4
DENSITY (LB/FT^3)	47.2	47.8
ANNUAL MWH	4738.8	4738.8

TABLE 1 – MEASUREMENT					
CASE (MTPY)	150	250	390	600	4300
CASE (MMSCFD)	7.95	13.25	20.67	31.80	227.88
PIPE SIZE	2"	3"	3"	4"	16"
BETA ORIFICE	0.60	0.50	0.65	0.60	0.60
METER RUN SIZE	2"	3"	3"	4"	16"

TABLE 2 – TEMP TRAPS			
LINE SIZE	BARREL SIZE	MAINLINE SIZE	KICKER SIZE
6"	8"	6"	4"
8"	10"	8"	6"
10"	12"	10"	6"
12"	16"	12"	8"
16"	20"	16"	12"
20"	24"	20"	12"

PIPELINE SIZING CRITERIA					
	MAXIMUM @ 2100 PSIG			PSID/MILE	FPS
	MBPD	MTCO2/Y	MMSCFD		
6"	9,980	558	29.57	10	10
8"	19,930	1,178	62.43	10	10
12"	39,860	3,250	172.23	10	10
16"	79,715	5,890	312.14	10	10
20"	119,660	10,560	559.63	10	10

REFERENCE DRAWINGS		REVISIONS						
		D	ISSUED FOR APPROVAL	BSP	JAS	JAS	03/02/22	
		C	ISSUED FOR APPROVAL	BSP	JAS	JAS	02/28/22	
		B	ISSUED FOR REVIEW	BSP	JAS	JAS	02/22/22	
		A	ISSUED FOR REVIEW	BSP	JAS	JAS	02/15/22	
DRAWING NO	DESCRIPTION	No	DESCRIPTION	BY	CHKD	APPV'D	DATE	

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HEARTLAND GREENWAY SYSTEM

HGS-2201-F-00002
MATERIAL AND ENERGY BALANCE

SCALE:	PROJECT NO:	DRAWING NO.	REV:
N.T.S.	2201-0001	HGS-2201-F-00002	D